MULTISENSORS FOR SPACE

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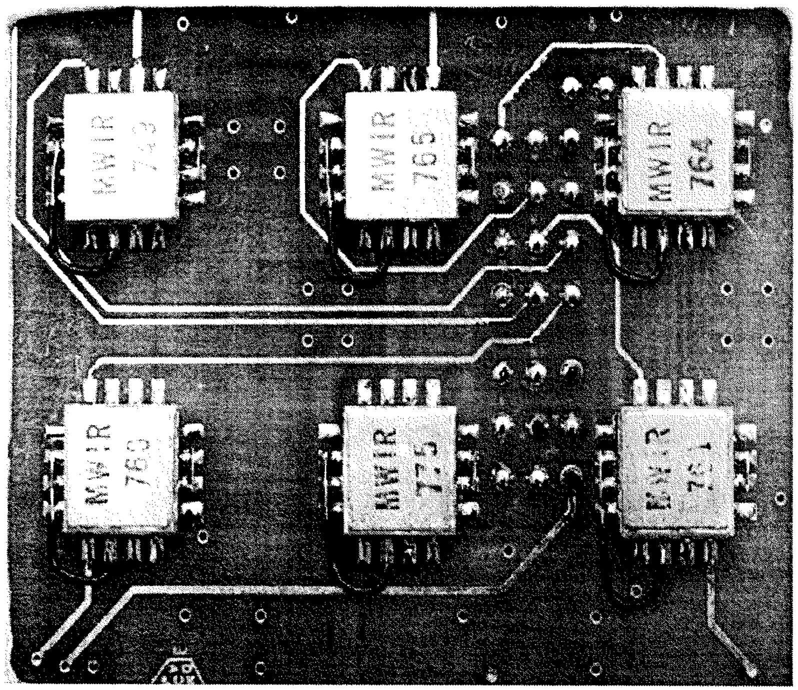
INTRODUCTION

- MULTI-SENSOR ARRAYS
  - RADIATION MONITOR
  - MARS OXIDATION EXPERIMENT
  - ION SELECTIVE ELECTRODES
  - ELECTRONIC-NOSE
- SENSOR COMPARISON
- FUTURE IMPROVEMENTS/RECOMMENDATIONS

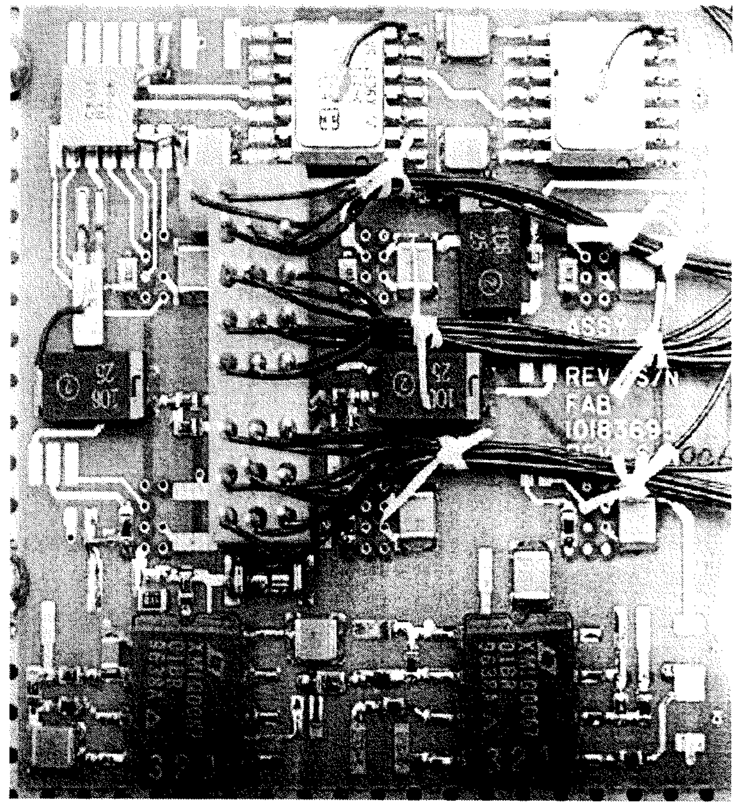
MULTISENSOR DESCRIPTION

SENSOR	SENSING MECHANISM	MEASUREMENT	ARRAY ELEMENTS	INSTRUMENTATION	MEDIA
Radiation Monitor	MOSFET VT shift due to gate-oxide charging	Particle radiation dose	96 STRV-1d	Detector, shields, and ohmmeter	Vacuum Air/gas Water Solid
Mars Oxidation Experiment	Fiber optic film reflectance change due to soil reaction	Soil composition	96 Mars'96	Detector, laser, fiber optic cable, sensor head	Solid
Ion Selective Electrodes (ISE)	ISE potential generated due to ion gradient across membrane	Ion and gas concentration in water	30 Mars'01/ MECA	ISE and voltmeter	Water
Electronic-Nose	Polymer resistance change due to gas exposure	Residual gas concentration in air	32 STS-95	Chemoresistors, filters, pump, solinoid, ohmmeter	Air/gas

RADIATION MONITOR FOR STRV-1d



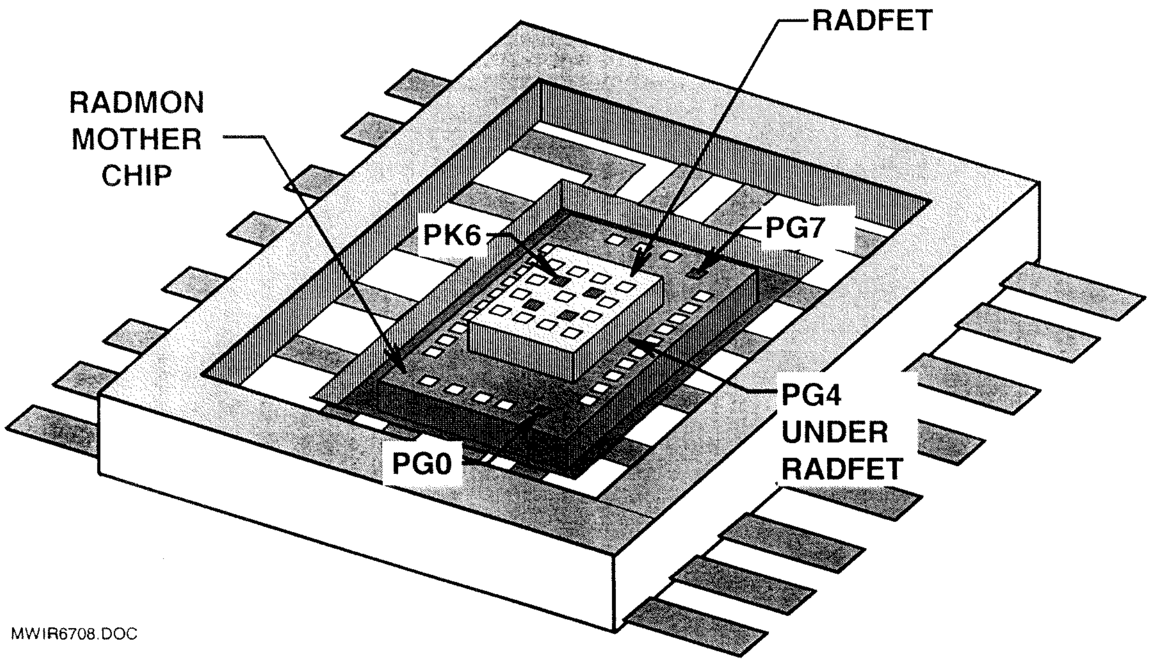
Top view



Bottom view

- DCM board is 5 cm x 5 cm.
- Each board has six Integrated Dose Modules (IDMs) with 24 p-FET dosimeters.
- IDMs individually shielded thus forming a simple radiation spectrometer

RADIATION MONITOR



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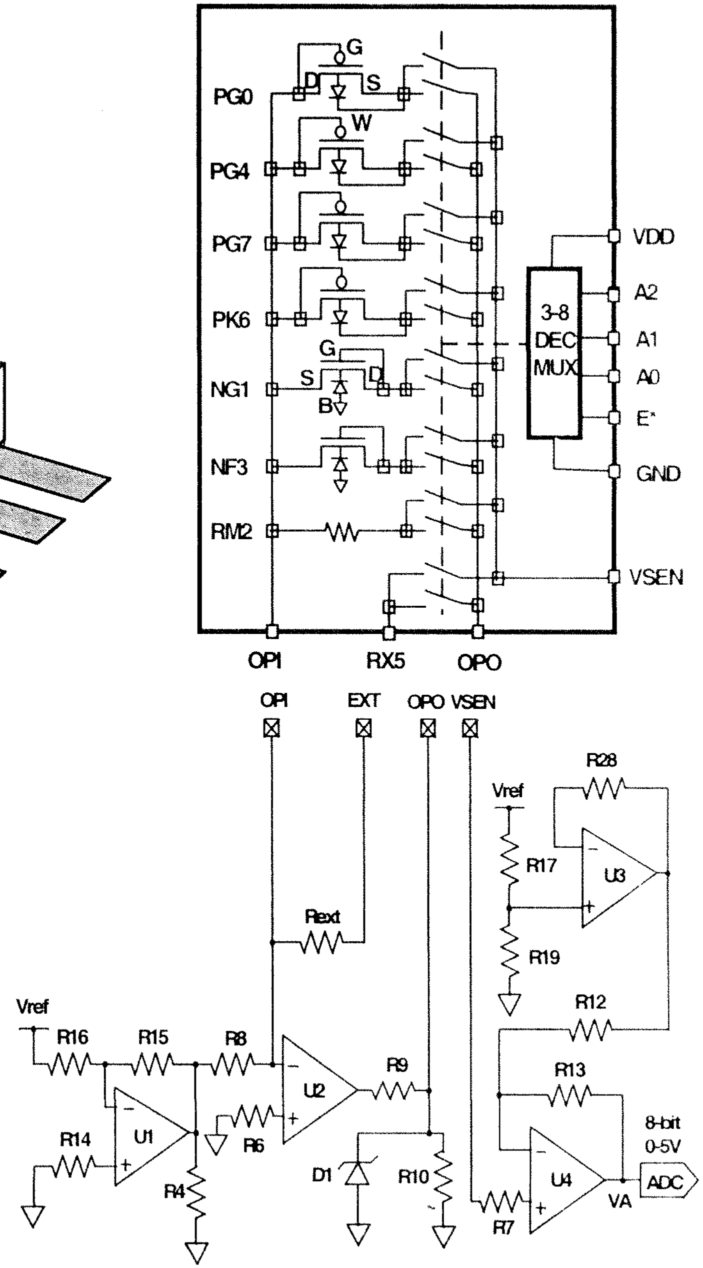
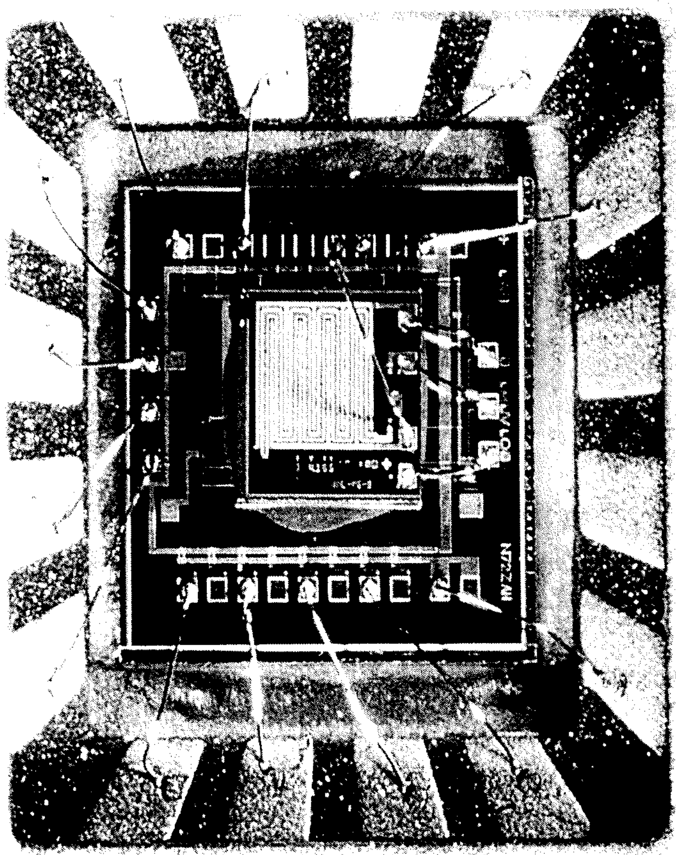


INTEGRATED DOSE MONITOR (IDM)

- **Package contains four p-FET dosimeters.**
- **RADFET covers PG4 adding 20-mils of Si shielding.**
- **p-FETs PG0 and PG7 are unshielded.**
- **Three dose rates expected in this package.**

RADIATION MONITOR FOR STRV-1d



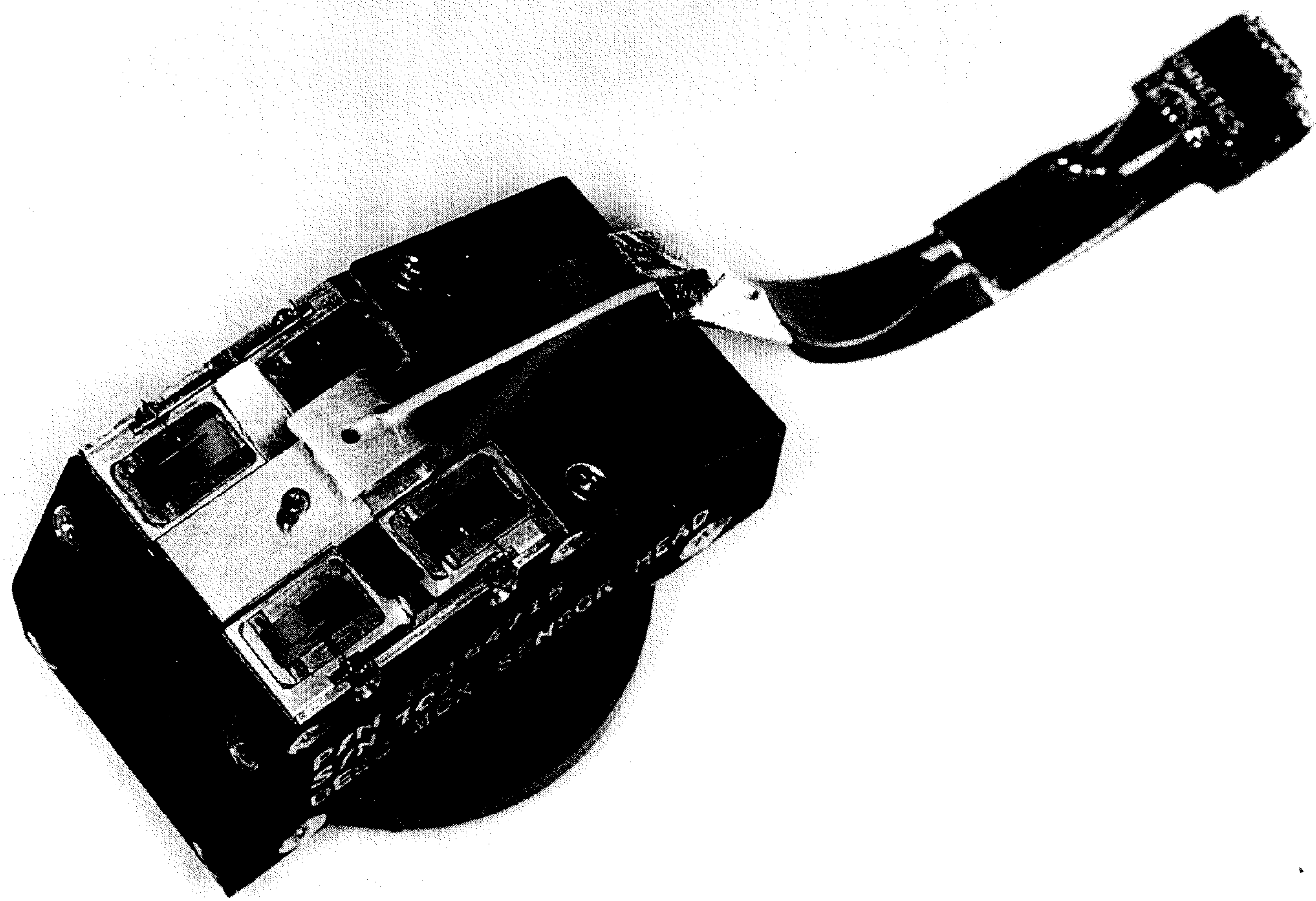
- Dose determined from p-FET threshold shift due to radiation-induced gate oxide trapped charge.
- In Earth orbit, radiation consists of electrons and protons
- On Mars, radiation consists of solar flare and Cosmic Ray particles.

NO.	DEVICE	LAYER
PG0	p-FET	Poly Gox
NG1	n-FET	Poly Gox
RM2	Resistor	Metal-1
NF3	n-FET	Metal Fox
PG4	p-FET	Poly Gox
RX5	Resistor	External
PK6	p-RADFET	Dual Dielectric
PG7	p-FET	Poly Gox

- Range: 200 rads to 2 Mrads
- Operational Power: 50 mW
- Operational Mode: Dosimetric

- Two chips are mounted in 16-pin leadless chip carrier.
- Mother chip is 1.8 mm x 2.2 mm and RADFET is about 1mm x 1 mm.

MARS OXIDATION EXPERIMENT FOR MARS'96



• Sensor head contains two LED at two wavelengths, four soil cell assemblies, four air cell assemblies, connecting fiber optics, line array detector, and conditioning electronics. Sensor cells hermetically sealed. Seal deployment mechanism is contained within sensor head assembly.

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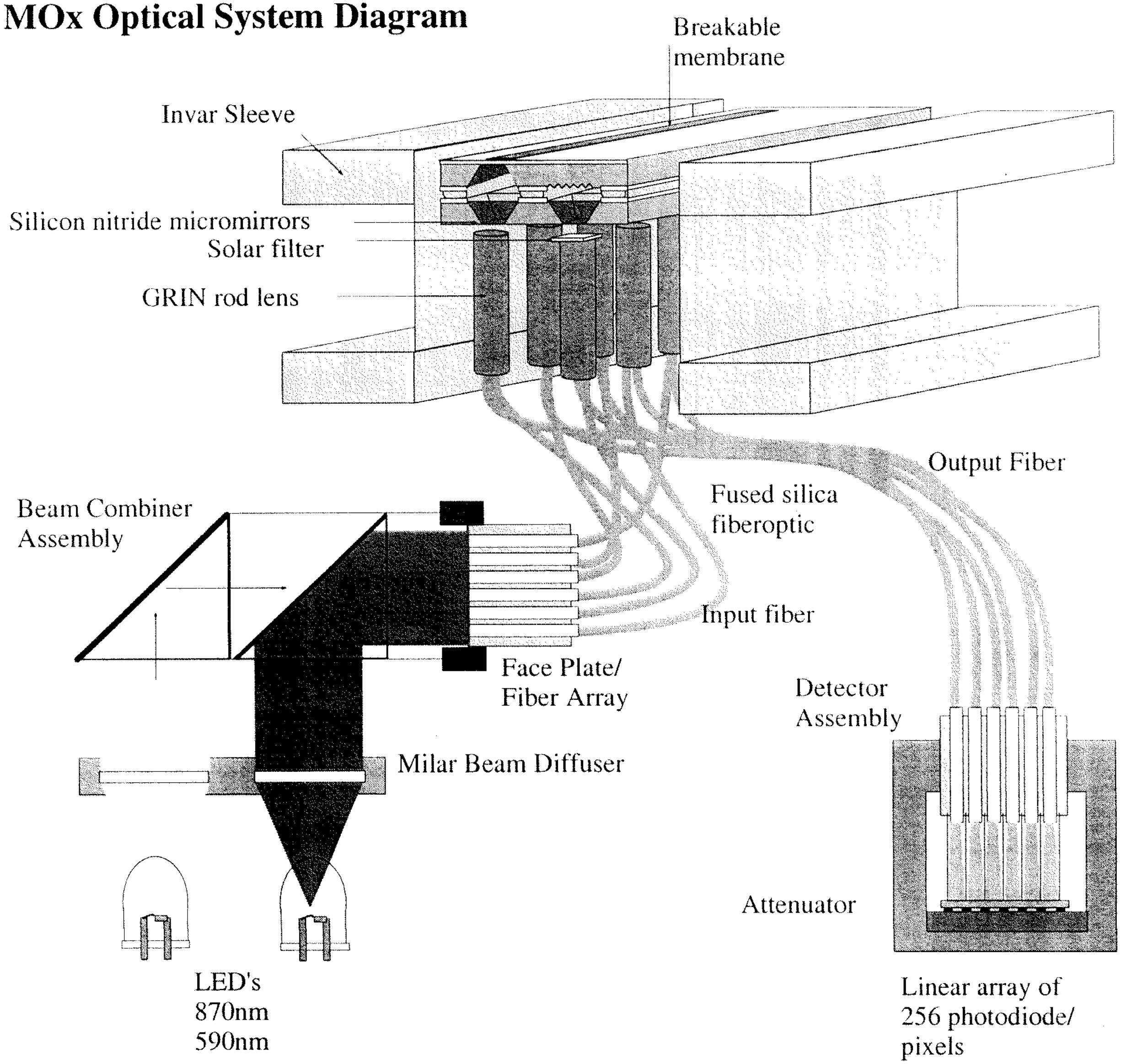
MARS OXIDATION EXPERIMENT

MOx Optical System Diagram



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MARS OXIDATION EXPERIMENT

COATING	PURPOSE
Magnesium	Very high reactivity to oxidants
Aluminum	High reactivity to oxidants; oxide is allowing intrafilm reaction
Titanium	Moderately high reactivity to oxidants; well studied in the laboratory
Vanadium	Moderate-to-high reactivity to oxidants; rich and variable oxide chemistry
Silver	Low reactivity, but extremely reactive to ozone, oxygen radicals, sulfur compounds
Palladium	Low reactivity but sensitive to hydrogen, sulfides, unsaturated hydrocarbons
Thin gold	Frost indicator; reactive to sulfur compounds; organic adsorption indicator (+2.0 nm Cr) Constant-reflectivity reference (+40.0 nm Cr)
Thick gold	Constant-reflectivity reference (+40.0 nm Cr)
Hydrocarbon-A	Analog of highly refractory kerogens(organics) found in meteoritic infall
Hydrocarbon-B	Analog of moderately refractory kerogens (organics) found in meteoritic infall
C60	Carbonaceous material, sensitive to combination of UV and oxidants
L-cysteine	To detect enantiomeric preference in reactions with, or catalyzed by, martian soil
D-cysteine	To detect enantiomeric preference in reactions with, or catalyzed by, martian soil
Thymol blue	pH indicator dye: pK1 = 2.0, pK2 = 8.8
Bromphenol blue	pH indicator dye: pK = 4.0
Bromcresol purple	pH indicator dye: pK = 6.3
Bromcresol purple	Fluoresces only at neutral or basic pH
Chlorophyllin	Ozone detection via ozonolysis of carbon-carbon double bonds
Iron porphyrin	May bind CO with color change
Copper Pc	Well-characterized sensor material for oxidants(Pc = phthalocyanine)
Lead sulfide	Reacts with hydrogen peroxide with large color change
Uncoated	Dust accumulation, surface film buildup, and ambient light level reference

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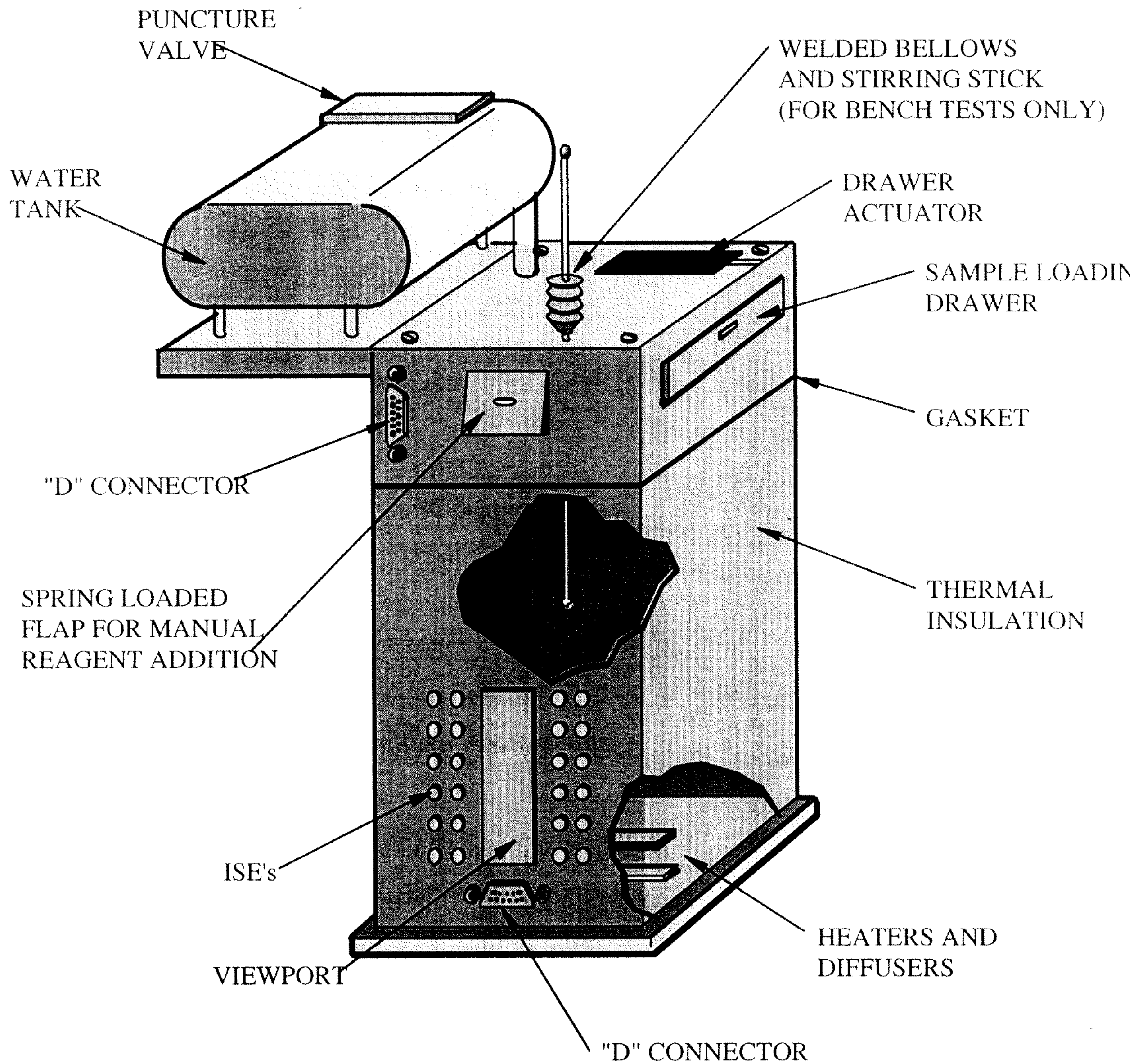
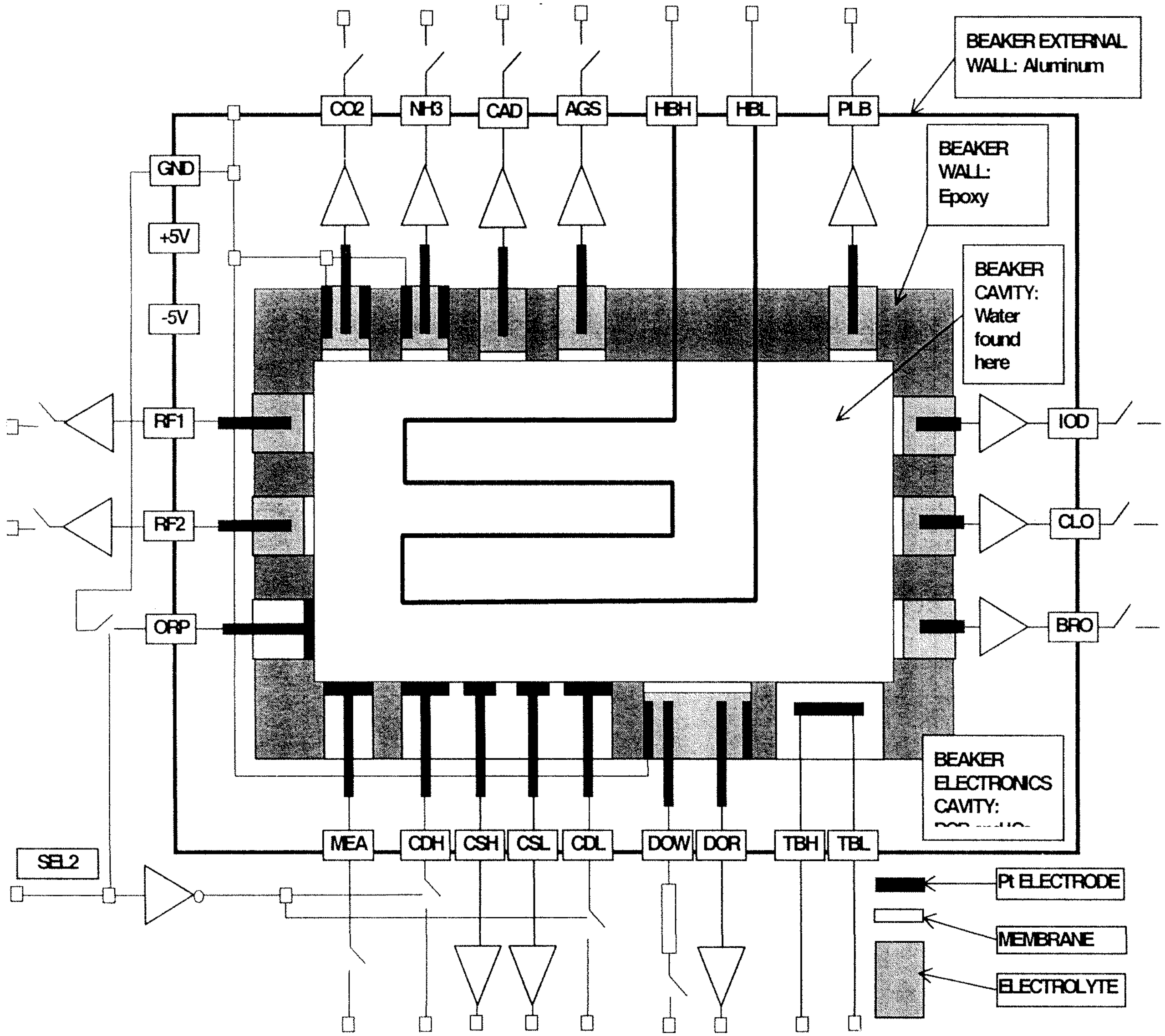
ION SELECTIVE ELECTRODES FOR MARS'01/MECA



ION SELECTIVE ELECTRODE BEAKER (Top View)



Ion Detectors: 26

Gas Detector: 2

Conductivity Detector: 1

Disolved Oxygen Mon.: 1

Thermometers: 1

Heater: 1

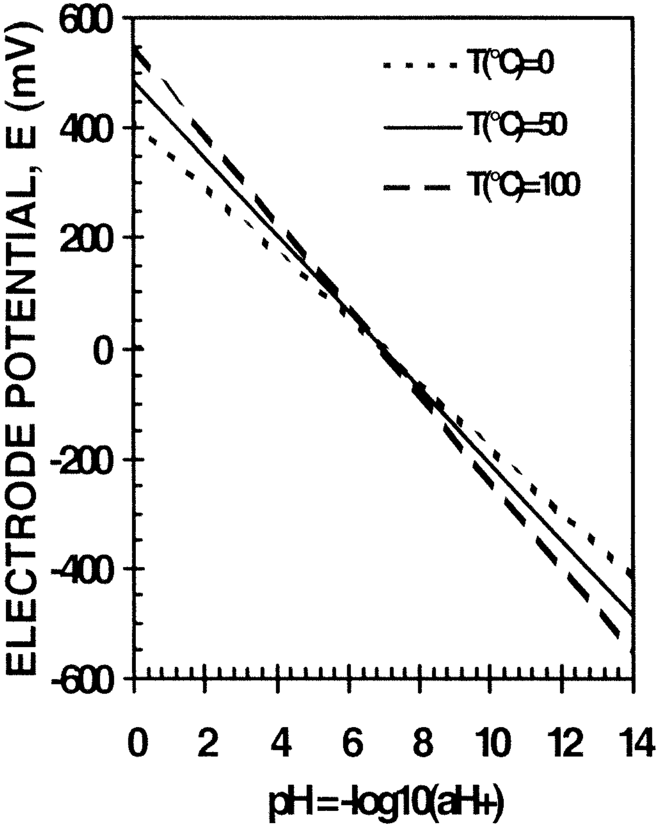
Ext. Dim.: 4.5x4.5x4.5 cc

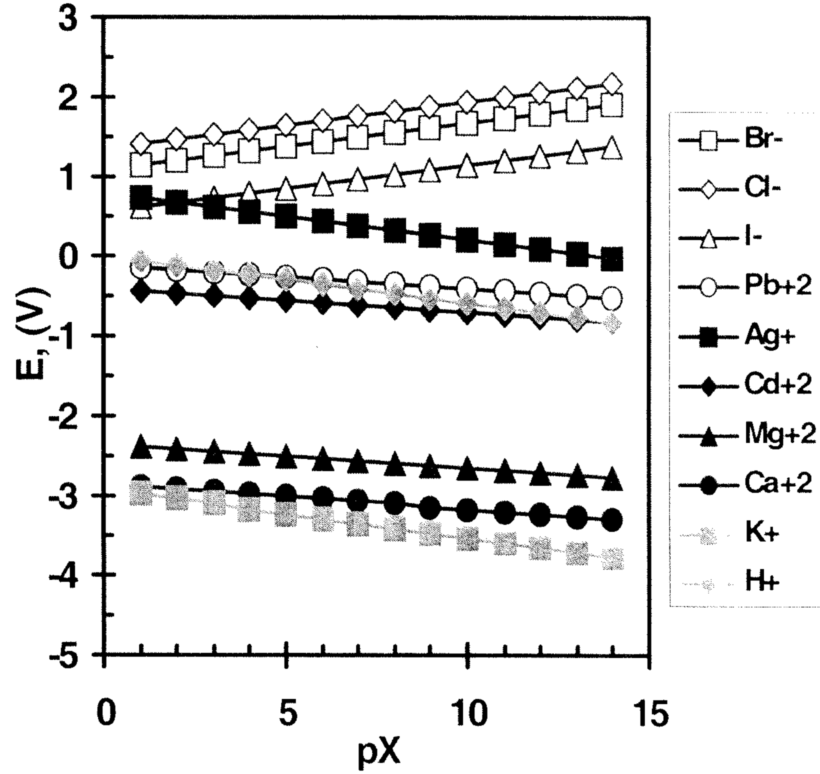
Operational Temp.: 20°C

Op. Pressure: ~1000 mb

MECA WET CHEMISTRY LABORATORY: Theory

Nernst Equation: $E = E_0 + S \cdot \log_{10} a_i$





- ISEs detect ion concentration(pX) in water via the potential generated by the ion concentration gradient across a membrane.

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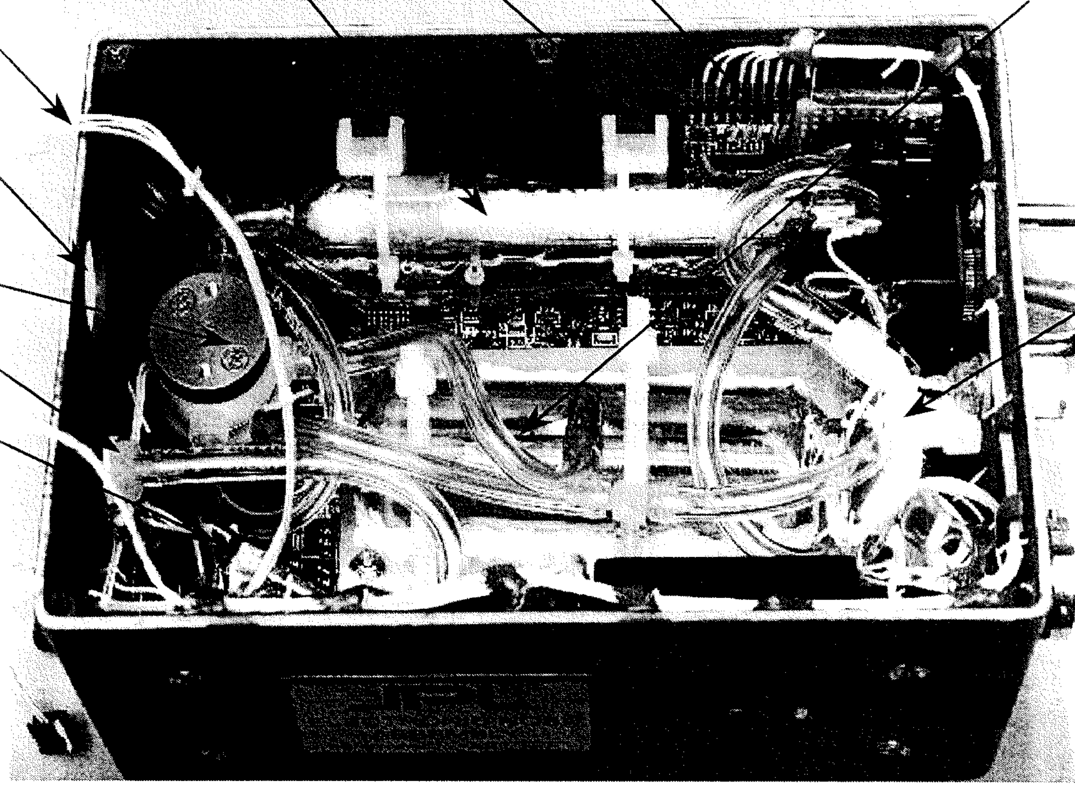
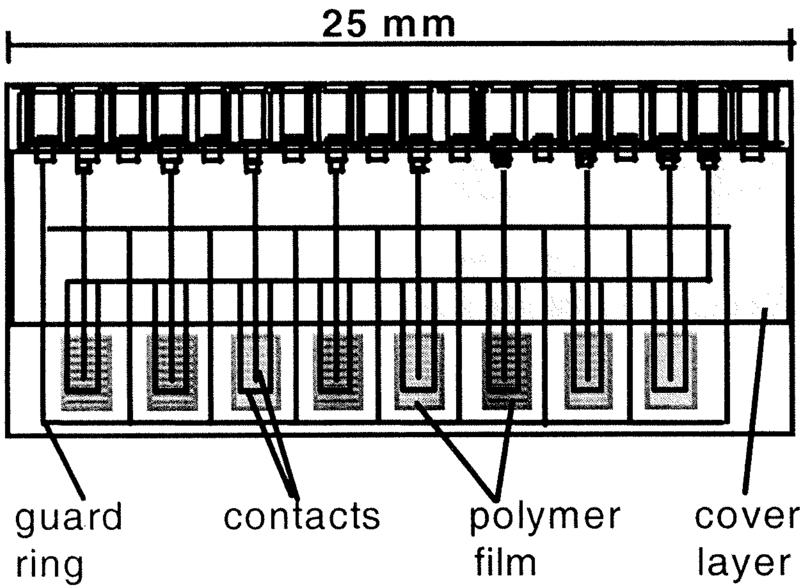
ELECTRONICS NOSE FOR STS95



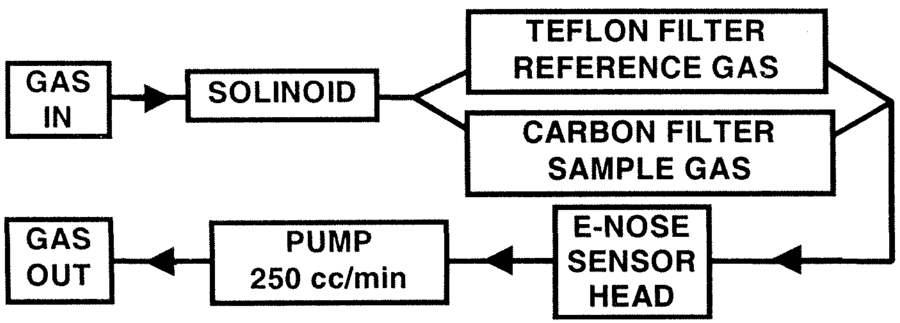
E-NOSE SHUTTLE EXPERIMENT

OBJECTIVE: Demonstrate E-Nose operation in space.

SENSOR CHIP



BLOCK DIAGRAM



Sensor designed as an air quality monitor and air controller and proposed here as a survey instrument.

DETECTION LIMITS

Compound	Detection Limit (ppm)
Methanol	25
Ethanol	50
2-propanol	50
Methane	3000
Ammonia	20
Benzene	10
Formaldehyde	10
Freon 113	50
Indole	0.03
Toluene	15

Detection limits governed by:
- Choice of polymers
- Baseline drift
- Gas flow over sensors
- Temperature (<50°C)

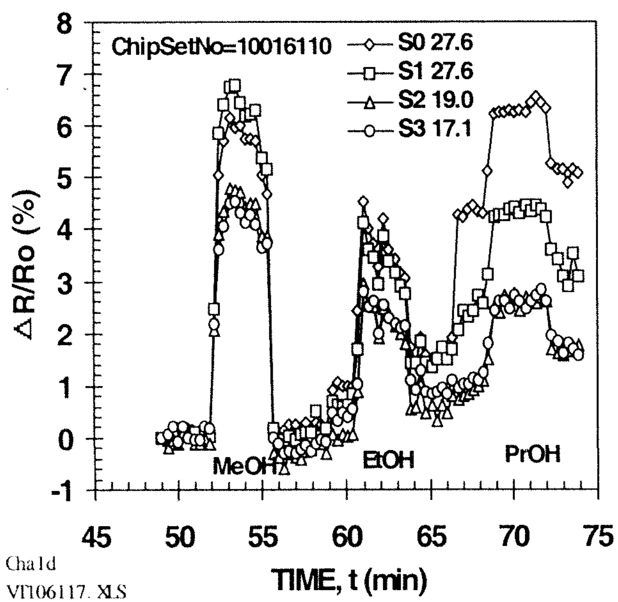
E-NOSE OPERATION

- E-Nose consists of an array of carbon doped polymers.

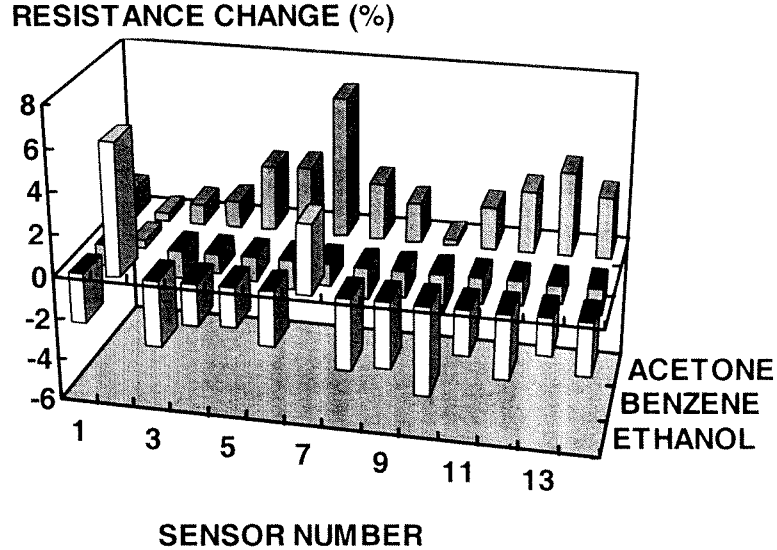
- Gasses cause polymers to swell preferentially which changes the polymer resistance.

- Resistance of polymer recovers when residual gas removed.

RESPONSE OF MeOH, EtOH, and PrOH



14 SENSORS EXPOSED TO 3 GASSES



- Sensor array is "trained" and the response entered into a data base. Gas identification via signature analysis using PCA or other data analysis techniques.

SENSOR OPERATION COMPARISON

SENSOR	DOSIMETRIC MODE	SENSOR AREA DEPENDENCE	REMOTE SENSING	ONE-TIME USE	NEED FOR DEPLOYMENT
Radiation Monitor	Yes	Yes, for point source No, for uniform field	Yes, depends on particle range	No, except for saturation	No
Mars Oxidation Experiment	Yes	No, if signal is above minimum detection	No, must touch soil	Yes, but can follow corrosion	Yes, must deploy sensor in soil
Ion Selective Electrodes	No	No	No, operates in water	No	Yes, must deploy sensor in water
Electronic-Nose	Yes, Potentially	No	Yes	No, except for aging.	No

CONCLUSION

- RADIATION MONITOR: Sensor is easily adapted to small satellites or explorers because it is small, requires low power, and can operate in the dosimetric mode.

- MARS OXIDATION EXPERIMENT: Requires contact with soil which involves a mechanism. Some miniaturization is possible.

- ION SELECTIVE ELECTRODES: The need to operate in water restricts the operating temperature and pressure to near STP. A mechanism is required to acquire a sample.

- ELECTRONIC-NOSE: Size and power can be reduced by 100x by eliminating filters, pump, and solenoid. Operation in stagnant air will allow Frisbee-like deployment with a radio link.